



Acute Diarrhea in Children

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Diarrhea

- The WHO defines diarrhea as 3 or more loose or liquid stools per 24 hours, or more frequently than is normal for an individual person by two or more bowel motions.
- Diarrheal illness is the second leading cause of child mortality (*WHO 2017*).
- Diarrheal illness may consist of:
 - Acute watery diarrhea
 - Invasive (bloody) diarrhea
 - Chronic diarrhea (persistent ≥ 14 days).



Pathophysiology

- Infectious gastroenteritis.
- Systemic infection.
- Intra-abdominal surgical emergency.



Systemic infections with diarrhea

- Influenza
- Measles
- HIV infection...persistent diarrhea or recurrent acute diarrhea.
- Malaria
- Serious bacterial infections :
 - Pneumonia
 - UTI
 - Meningitis
 - Sepsis.



Surgical Emergencies

- Intussusception..... acute bloody diarrhea and severe intermittent abdominal pain; in some cases a cylindrical abdominal mass is palpable.
- Appendicitis



Gastroenteritis

- Acute Watery Diarrhea or bloody (invasive) diarrhea
- Microorganisms responsible for acute watery diarrhea:
 - Rotavirus: The most common causative agent in children < 2 years old
 - ETEC: The most common causative agent in older children & adults
 - Vibrio cholera O1 and O139
 - Cryptosporidium : common in infants < 1 year



Acute Watery Diarrhea

- It is usually not necessary to identify a specific microbiologic diagnosis in order to provide supportive care
- Antibiotics are not usually indicated.
- In cholera there is a short history (usually < 24 hours) of vomiting and passage of voluminous watery diarrhea, which may have a characteristic rice-water appearance, associated with severe dehydration.

Bloody Diarrhea

- Shigellosis is the most common etiology.
 - *Shigella dysenteriae*
 - *Shigella Flexneri*..... The predominant species in children.
 - *Shigella boydii*
 - *Shigella sonnei*.
- *Salmonella enterica*
- *Campylobacter* spp.
- Enterohemorrhagic *E. coli*....produces Shiga-like toxin: HUS
- Enteroinvasive *E. coli*
- *Entamoeba histolytica*.

History

Exposures

- Childcare center attendance
- Travel to diarrhea-endemic area
- Visit to farm or petting zoo
- Use of antimicrobial agents
- Contacts with similar symptoms
- Food exposures: seafood, unwashed produce, unpasteurized milk or dairy products, or incompletely cooked meats

Assess hydration status

Presentation

- Symptom onset and duration
- Stool frequency and consistency
- Presence of mucus and blood
- Other associated symptoms: fever, vomiting, abdominal pain, headache, cough, urinary symptoms, skin rash and seizures



Physical Examination

- **Temperature**
- **Respiratory tract**
 - Tachypnea can be a sign of pneumonia in the setting of cough or difficulty breathing
- **Abdomen:** signs of UTI, appendicitis
- **CNS:** Moderate dehydration can lead to irritability; severe dehydration can lead to lethargy and coma.



Diagnostic Tests

- Most children with acute diarrhea do **not** require laboratory testing.
- Patients with seizures or altered consciousness should have glucose and electrolyte assessment.
- Children with suspected pneumonia, sepsis, meningitis, UTI should have the relevant investigations.
- Imaging studies are warranted for patients with acute abdominal findings on physical examination.
- Stool Studies: Stool Microscopy, Stool Culture, enzyme immunoassay and latex agglutination assay.

Stool Studies

- **Stool pH & microscopy:** to look for the presence of WBCs, RBCs, ova & parasites (e.g. *G. lamblia* and *E. histolytica*):
 - pH<5 goes with viral infection.
 - **Fecal leukocytes** are present in bacterial or enterovirus infections.
 - When Cholera is suspected: using dark field microscopy to detect motile *Vibrios*, which appear as "**shooting stars**".
 - In the setting of acute bloody diarrhea: direct microscopic evidence of ***Entamoeba* trophozoites containing RBCs** is sufficient to diagnose amoebic dysentery (rather than shigellosis) .
 - Patients with invasive diarrhea who do not respond to empiric antibiotic therapy.

Stool Studies, cont'd

- **Stool cultures** should be considered early in the course of illness for:
 - Bloody or prolonged diarrhea
 - The presence of leukocytes;
- In these cases: Culture for Salmonella, Shigella, Y. enterocolitica and Campylobacter spp
- Culture for Escherichia coli, particularly O157:H7, with bloody diarrhea and a history of eating ground beef
- **Rapid antigen testing of the stool:**
 - **Enzyme immunoassay** of the stool can be used to detect antigens of Rotavirus, adenovirus and Giardia Lamblia.
 - **Latex agglutination assay** for Rotavirus



Complications of acute diarrhea in children

- Dehydration and electrolyte imbalance
- Malnutrition in recurrent diarrhea
- Hemolytic Uremic Syndrome
- Convulsions, which can be due to:
 - Electrolyte disturbances: Hypoglycemia, hyponatremia, hypernatremia
 - Severe disease due to shigella, and less commonly systemic salmonella infection
 - Meningitis
 - Febrile seizures
- Intussusception following severe Rotavirus infection



Treatment for Infectious Diarrhea

- Fluid and electrolyte management
- Nutrition
- Antibiotics



Assessment for Dehydration, WHO

- The presence of 2 of the following signs can mark the presence of **some amount of dehydration (5-10% dehydration)**
 - Restless, irritable
 - Sunken eyes
 - Thirsty, drinks eagerly
 - Skin pinch goes back slowly
- The presence of 2 of the following signs can mark the presence of **severe dehydration (>10% dehydration):**
 - Lethargic or unconscious
 - Sunken eyes
 - Not able to drink or drinking poorly
 - Skin pinch goes back very slowly

Clinical features in children with dehydration

Clinical Feature	Mild (3-5%)	Moderate (5-10%)	Severe (>10%)
General Appearance	Restless	Irritable, restless	Lethargic, unconscious
Tears	Normal	Normal or reduced	Absent
Eyes	Normal	Slightly sunken	Deeply sunken
Mucous Membrane	Normal or slightly dry	Dry	Parched
Fluid Intake	Thirsty	Thirsty, drinks eagerly	Drinks poorly
Skin Turgor	Normal	Reduced (recoils in <2s)	Reduced (recoils in >2 s), tenting
Capillary Refill Time	Normal (<2s)	Delayed (>2s)	Very delayed (>3s)
Blood Pressure	Normal	Normal to low	Hypotension
Pulse Rate	Normal	Tachycardia	Tachycardia or bradycardia
Respiratory Rate	Normal	Increased	Deep
Fontanelles	Normal	Depressed	Markedly depressed
Urine Output	Normal or slightly reduced	Markedly reduced	Absent for several hours



Fluid Management

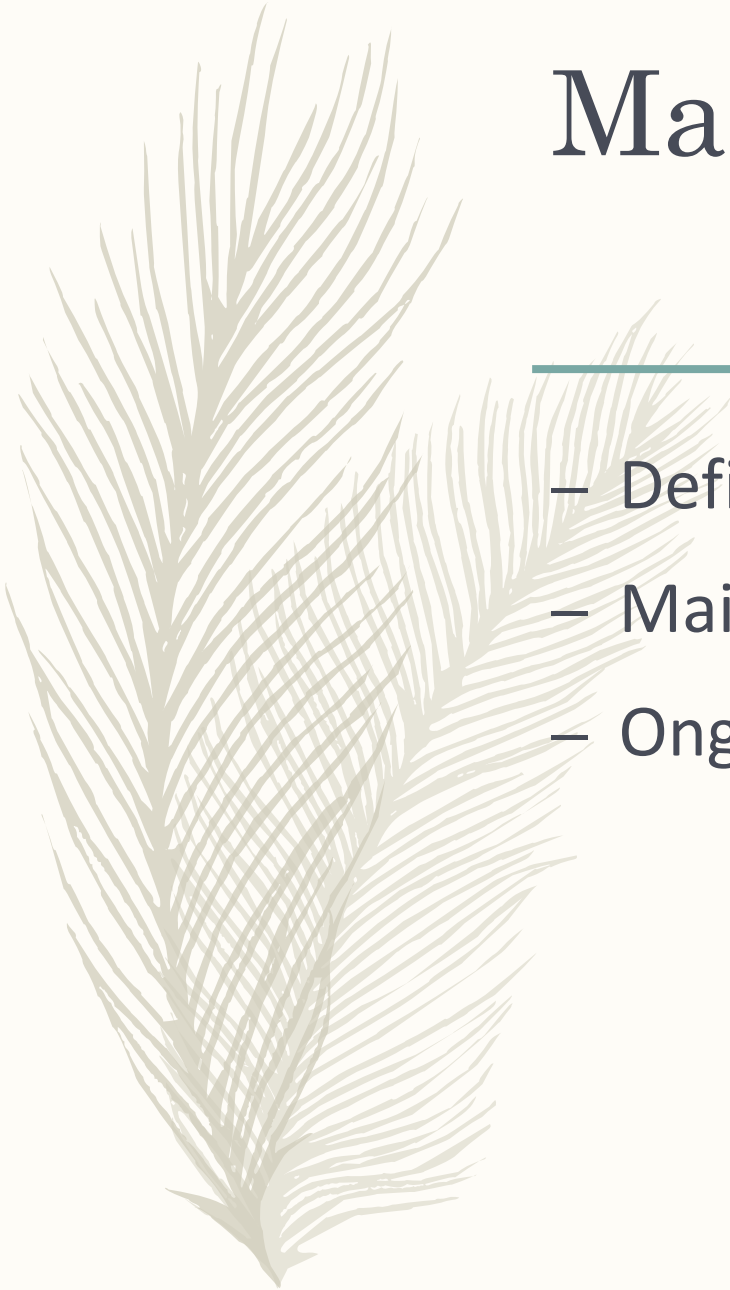
- Fluid loss in acute watery diarrhea can be isonatremic, hyponatremic, or hypernatremic.
- Most children with acute diarrhea should be treated with Oral Rehydration Solution (ORS), a mixture of water, salts, and glucose, in both the replacement and maintenance phase.
- The WHO and the UNICEF recommend a reduced-osmolarity formulation of ORT to avoid the risk of hypernatremia
- Advantages of ORT include lower cost, elimination of the need for IV line placement, and involvement of the parents in a rehydration process they can continue at home and utilize in future illnesses.
- The advantage of correcting sodium imbalances with ORS is that the correction occurs relatively gradually, reducing the risk of the neurologic complications due to rapid shifts in osmolarity that may occur with intravenous fluids.

Composition (mEq/L) of common solutions used for rehydration

Route	Solution	Na+	K+	Cl-	HCO ₃ ⁻	Citrate	Ca ⁺⁺	Glucose/carbohydrate
Intravenous	Normal saline	154	-	154	-	-	-	-
	Ringer's Lactate	130	4	111	28	-	3	-
	Ringer's Lactate + 5 percent dextrose	130	4	109	28	-	3	278
	Cholera saline ("Dhaka solution")	133	13	98	48	-	-	140
Oral	Standard ORS	90	20	80	-	10	-	111
	Hypo-osmolar ORS	75	20	65	-	10	-	75
	ReSoMal* (Reduced Osmolarity ORS for Malnourished Children)	45	40	76	-	7	-	125

Management of Dehydration


- Deficit repletion (rehydration phase)
- Maintenance fluids
- Ongoing losses





Deficit Replacement

- Not required in patient with <5% dehydration
- Accomplished with ORS administration at a volume of 50-100 mL/kg over 4 hours in patients with 5-10% dehydration.
- Accomplished with IVF administration in patients with >10% dehydration
- Replacement fluids should be continued under supervision until all the initial signs of dehydration are absent and the patient has urinated. This may require more fluids than initially estimated.



Mild-to-Moderate Dehydration Deficit Replacement

- These patients have **some dehydration** according to WHO classification (5-10% dehydration)
- ORS is administered to replace the deficit at a volume of 50-100 mL/kg over 4 hours.
- We may consider IVF bolus of 10ml/kg over 30-60 minutes in patients with moderate dehydration
- Given in small amounts by spoon or syringe (5 mL every 1-2minutes).
- If the patient is breastfed, breastfeeding continues during this phase as well as during the maintenance phase.



Severe Dehydration Deficit Replacement

- The goal of rehydration with IVFs is to stabilize the circulation immediately
- IV therapy with rapid infusion of 20-30 mL/kg of isotonic saline to be replaced over 30 min (1 hr in infants <12 mo), followed by additional isotonic fluids to correct the bulk of the remaining fluid deficit, by giving 70 mL/kg of isotonic saline over 2.5 hours (or 5 hours for infants).
- ORS should be initiated in addition to IVF as soon as the patient can drink, since commercial isotonic IVF solutions primarily replace water and Na but do not replace glucose, K , or other electrolyte losses.
- If seizures are present (and hypoglycemia is suspected), a rapid bolus of IV glucose should be given followed by addition of 5 % glucose to the IVF.



Maintenance Phase

- Once repletion is completed, feeding and fluids should be started.
- It is usually accomplished with ORS even in patients with initial severe dehydration
- For patients with initial $<5\%$ dehydration ORS is the optimal maintenance fluid but other fluid options for those patients can be acceptable like:
 - Water, salted rice water or salted yogurt drinks, salted vegetable or meat soups.
 - Fluids not accepted: carbonated beverages or sweetened juices.

Calculation of maintenance fluids based on body weight (Wt) in children and infants

Body Wt (kg)	Daily maintenance fluid (mL/24 hours)	Hourly maintenance fluid (mL/hour)
1 to 10	$100 \times \text{Wt (kg)}$	$4 \times \text{Wt (kg)}$
>10 to 20	1000 plus $50 \times \text{Wt over 10 kg}$	40 plus $2 \times \text{Wt over 10 kg}$
>20	1500 plus $20 \times \text{Wt over 20 kg}^*$	60 plus $1 \times \text{Wt over 20 kg}^*$

* Maximum maintenance fluid per 24 hours is 2400 mL or 100 mL/hour.



Ongoing Losses

- During the deficit replacement and the maintenance phases reassessment of the patient's hydration status and replacement of ongoing losses should occur hourly.
- 10 mL/kg of body weight of ORS should be administered for each watery or loose stool, and 2 mL/kg of body weight for each episode of emesis.
- The total hourly loss should be added to the amount to be given over the next hour.



Nutrition

- We should aim to prevent malnutrition and chronic enteropathy.
- Infants with diarrhea should be encouraged to breastfeed as much as possible .
- Infants that are not breastfed should be encouraged to continue to take undiluted formula at least every 3 hours, in addition to ORS.
- Children with diarrhea should be encouraged to take solid foods immediately after initial dehydration is corrected to prevent malnutrition.



Nutrition, cont'd

- During the refeeding period, certain foods, including complex carbohydrates (rice, wheat, potatoes, bread, and cereals), lean meats, yogurt, fruits, and vegetables, are better tolerated than other foods.
- Fatty foods and foods high in simple sugars (including juices and soft drinks) should be avoided.
- As long as diarrhea persists, foods high in energy content and micronutrients should be offered at frequent intervals (at least 6 meals a day).
- After diarrhea resolves, at least 1 extra meal per day should be continued for a minimum of 2 weeks, or until the patient regains normal weight-for-height.



Zinc Supplementation

- The WHO recommends zinc for children under 5 years of age with diarrhea (10 mg/day for children under 6 months and 20 mg/day for children 6 months to 5 years, each for 10-14 days).
- To reduce the severity and duration of diarrhea and reduce the incidence of subsequent episodes of diarrhea for several months



Antibiotics

- Not indicated for most children with acute watery diarrhea; **suspected cholera** is an important exception .
- Empiric therapy may be appropriate in the presence of a severe illness with bloody diarrhea and stool leucocytes, particularly in infancy and the immunocompromised.
- Empiric antibiotic therapy for acute bloody diarrhea should be targeted against Shigella species:
 - Reduces the duration of fever and diarrhea
 - Decreases the duration of bacterial shedding
 - May reduce the risk of life threatening complications of infection such as bacteremia .
- Amebic dysentery does not respond to anti-Shigella therapy. Direct stool microscopy can be used for presumptive diagnosis.
- Antibacterials should be **avoided** when enterohemorrhagic E- coli infection is suspected clinically.



Choice of Antibiotics

- For suspected **shigellosis** :
 - **Azithromycin** PO: 15mg/kg Day 1, followed by 10mg/kg daily Days 2-5
 - Cefixime PO: 8 mg/kg per day orally in one or two divided doses for 5 days
 - **Ciprofloxacin** PO: 30mg/kg/Day (divided BID) for 3 days, not first-line in children <18 years
 - TMP-SMX PO: 10 mg/kg (based upon TMP component) divided BID for 5 days. Should be used only if the isolated strain is susceptible.
 - Ceftriaxone IV: 50-100mg daily (divided QID) for 2-5 days, given for severe infections or infections refractory to initial therapies
- **Metronidazole**
 - Amebiasis :35-50 mg/kg per day in 3 divided doses for 7-10 days
 - Clostridium difficile: 30 mg/kg/day in 4 divided doses for 7-14 days
 - Giardiasis: 15 mg/kg/day in 3 divided doses for 5-7 days
- The antibiotic options for **cholera** include **macrolides**, **fluoroquinolones**, and **tetracyclines**.



Prevention of infectious diarrhea

- Public and personal hygiene
- Breastfeeding
- Vaccines to prevent rotavirus and hepatitis A infections are recommended.

Rotavirus Vaccines

- Live virus vaccine, administered orally.
- RotaTeq should be given in 3 doses(each 2ml) administered at 2, 4, and 6 months of age.
- Rotarix should be given in 2 doses(each 1-1.5ml) administered at 2- and 4 months of age.
- Infants who have had rotavirus gastroenteritis before getting the full course of vaccine should still initiate or complete the recommended schedule; initial infection provides only partial immunity.
- Most frequent adverse reactions: Fussiness & irritability(<52%).
- Other adverse effects :diarrhea, vomiting, OM and nasopharyngitis.
- Use of RotaTeq and Rotarix is C/I with a history of intussusception.



Hemolytic Uremic Syndrome

- HUS is the most common cause of acute kidney injury in children.
- Progressive renal failure that is associated with microangiopathic hemolytic anemia and thrombocytopenia.
- 90% of cases of HUS in children follow a diarrheal prodrome and is associated with the production of Shiga toxin:
 - In 70% of the cases it is due to EHEC (particularly type O157:H7),
 - May also be induced by *S. dysenteriae* serotype 1.
- Acute kidney injury occurs in 55-70% of patients, but they have a favorable prognosis, and as many as 70-85% of patients recover renal function.
- Approximately 15-20% of children may develop hypertension 3-5 years after the onset of disease.



HUS Classification

- Primary (Hereditary causes).
- Secondary (Acquired causes):
 - Infection:
 - Shiga toxin-producing Escherichia coli (STEC)
 - Streptococcus pneumoniae
 - HIV infection
 - Autoantibodies to complement factors
 - Drug toxicity, particularly in patients with cancer or solid organ transplant recipients
 - Rare occurrences in pregnant patients or those with autoimmune disorders (eg, SLE)



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